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The Economic Value of the Western Meadowlark in California

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FIG. 1.—Western Meadowlark (*Sturnella neglecta*). (Original.)

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INTRODUCTION.

Lest certain birds noted for their occasional depredations be unwittingly destroyed before their real value to the agriculturalist was found out, and in order to prevent a recurrence of such an economic loss as is exemplified in the extinction of the passenger pigeon, the California State Fish and Game Commission, in cooperation with the University of California,* decided to carry on a thorough, scientific investigation into the relation of certain birds about which complaint has been made. In so doing, they have hoped to present unprejudiced evidence as to the value of the birds concerned, thus making an adequate basis for legislation.

For a number of years grain growers have complained of damage to sprouting grain caused by western meadowlarks (*Sturnella neglecta*). These birds have been accused, and rightly so, of digging down beside the sprout and pulling off the kernel of grain. Ranchers have maintained that in some cases whole fields of grain have had to be reseeded because of the great loss occasioned by the birds.

An unsuccessful attempt to take protection away from the meadowlark has been made in the last two legislatures. The failure of the first bill to pass led the adherents of the measure to modify the second bill so as to take protection from the bird only in those counties where it was known to cause considerable damage.

For these reasons the investigation by the California State Fish and Game Commission into the relation of birds to agricultural and other interests of the State has been directed primarily toward a determination of the economic value of the western meadowlark.

The real value of a bird can only be determined after a careful study of both direct and indirect benefits conferred by it and the injuries which it causes, as well as its entire life history. Consequently in this investigation a number of methods have been used. Field investigation has been relied on to furnish evidence as to the kind and the extent of the injuries to crops, and to the life history of the bird and of the relation of birds to insect outbreaks. Experimentation has been relied upon to furnish evidence as to the quantity of food required, and as to the time of digestion. Evidence as to the food habits has been largely furnished by laboratory examination of the contents of the stomachs of birds collected for that purpose.

COLLECTION OF NON-GAME BIRDS.

Birds in sufficient numbers to furnish reliable data, collected every two weeks during a year, and from over twenty different localities in the State, have been made available through the cooperation of the deputies of the Commission. Each bird has been tagged with data as to date, time of day, locality, kind of field or orchard, and collector. They have then been preserved in formalin. On the arrival of shipments at the laboratory the stomach (gizzard) has been removed, and data as to the species and sex of the different birds added. The tag

*Contribution from the Zoological Laboratory of the University of California, prepared under the direction of Professor C. A. Kofoid.

N. B. A technical report giving full details of the investigation is in course of preparation and will be published in the Zoological Series of the University of California Publications.

bearing complete data has then been wrapped with the stomach in a small cloth, and preserved in formalin until microscopically examined.

MATERIAL.

The accompanying map (Fig. 2) shows the localities in which collections have been made. The localities from which complete series, that is, birds collected each month of the year, were made and those localities from which incomplete series were obtained are indicated.

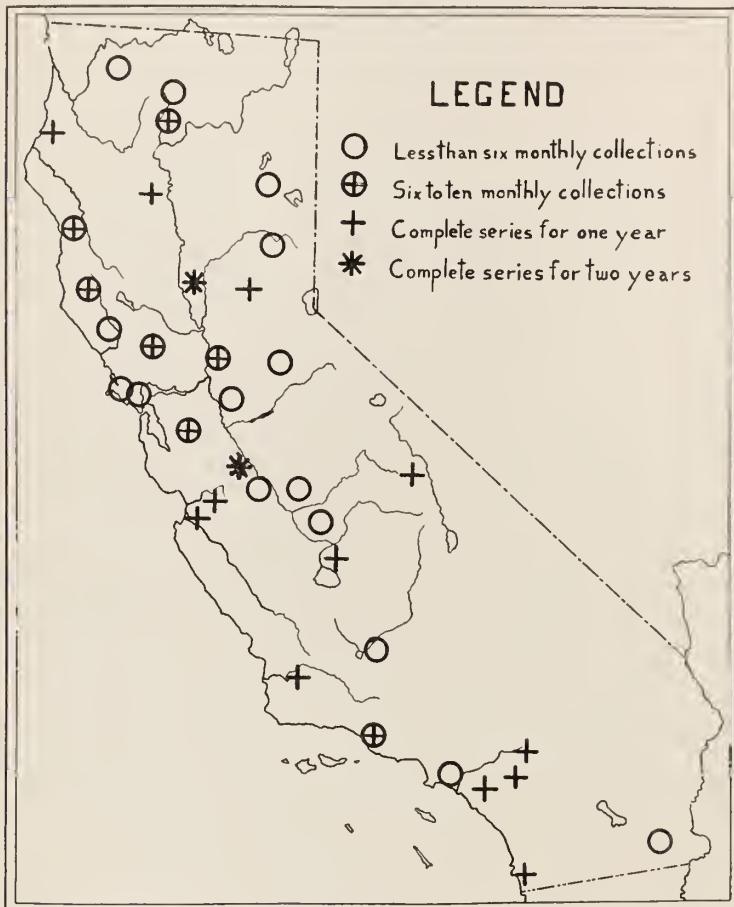


FIG. 2.—Map of California showing localities in which collections of non-game birds have been made for the purpose of stomach examination. The number of collections now available for stomach examination are indicated. A complete series is a minimum of six birds collected each month in a year.

In order that the work of 1911 might be verified, collections were continued in several places during 1912. This has afforded a comparison of the food in two succeeding years and has acted as a check on the results obtained.

Slightly over nineteen hundred stomachs of western meadowlarks have been available for examination. The contents of each stomach has been microscopically examined, and the number, kind, and percent-

age-volume of each article of diet has been recorded. The stomach contents have been preserved in every case, so that a verification of the work is at all times possible.

THE WESTERN MEADOWLARK.

The meadowlark is not a true lark, but belongs to the same family, Icteridæ, to which the blackbird and oriole belong. Since the meadowlark of the eastern United States differs from that found in the western States in both coloration and song, the bird of the west is termed the western meadowlark (*Sturnella neglecta*) (Fig. 1). The western meadowlark is a common bird from Wisconsin, Illinois, Iowa, Texas, etc., west to the Pacific coast, also ranging north into Canada and south into Mexico.

The meadowlark is well known because of its size, bright plumage and cheerful song. It is a conspicuous bird of treeless areas and a frequenter of the meadow and pasture. In California it is found from sea level to altitudes of 7,000 feet in the mountains. It is most abundant in the great central valleys where in some places the birds may be seen congregated in flocks of fifty or more. Censuses have shown that western meadowlarks are most often found in uncultivated, grassy fields.

The western meadowlark feeds almost entirely on the ground. When startled, it usually perches on a clod or fencepost and shows its antipathy to the intruder by noising continuously his "clerk-clerk-clerk." A squatting motion, accompanied with a flash of four white tail feathers by a spreading of the tail, also characterizes the startled meadowlark.

The western meadowlark appears to be one of the few birds which is profiting by the increased cultivation of land. Alfalfa furnishes particularly good food and cover for the bird and grain fields are often chosen for a home. With the furnishing of still more good food and cover, combined with the destruction of some of its enemies, the western meadowlark may be expected to still further increase in numbers.

In California the meadowlark is a resident bird, spending the whole year in the same general locality. There may be an occasional migration to or from higher altitudes with a shortage of food supply, but this is unusual.

DEPREDACTIONS.

Field investigation has shown that western meadowlarks do a considerable amount of damage in grain fields in some parts of the State. The most serious damage is done while the grain is sprouting. It is indeed astonishing the skillful way in which the bird follows the drill-row, bores down beside the sprout, and pulls out the kernel.

Ofttimes the kernel is simply crushed in the bill and the hull and sprout dropped beside the hole. For this reason examination of stomach-contents does not always show the total damage done. It is interesting to note, also, that this is not a new habit recently acquired. Dr. Elliott Coues called attention to this habit in 1874.

Oats appear to be preferred, for losses are greater in these fields, even when other grain is available. However, the destruction most nearly parallels availability. The damage is often considerable, especially where the birds are numerous and the area of the field small. In the fields inspected, damage was greatest in sandy soil, for here the grain

is more easily obtained. Next to the condition of the soil, the factor governing the extent of damage appears to be the proximity to pasture land or, in other words, to the natural habitat of the bird. Borders of fields near grass land suffer most. In some instances it was found that meadowlarks had followed the drill row for distances of four to six feet and apparently pulled every sprout. In broadeasted fields thinning was found to be considerable. In localities where meadowlarks are not numerous, practically no damage is done. The extent of damage varies directly with the numbers of the birds. Barley and wheat are attacked to a less extent. Field corn and sorghum are not damaged and no complaints have been received.

In spite of the fact that damage to sprouting grainfields is real, it is often exaggerated. A number of things minimizes both the real and the possible damage to sprouting grain. In the first place, meadowlarks



FIG. 3.—Holes bored by western meadowlarks in obtaining kernels of grain in sprouting grainfield. Photograph by H. C. Bryant taken at Lathrop, San Joaquin County, California, February 28, 1912.

can succeed in pulling the sprouting grain only when it first appears above the ground. After the second and third blades appear, the plant is well rooted and the kernel no longer essential to the life of the plant. Only the grain which is within one and one half inches of the surface is obtainable. Hence the difficulty of obtaining the kernel and the termination of the time during which the kernel is essential to the life of the plant soon makes destruction impossible. Probably in few cases is damage to sprouting grainfields extended over a period more than two weeks. Hard, dry soil precludes attack. Damage is greatest after the soil has been softened by rain.

Investigation has also shown that fields apparently greatly damaged by meadowlarks while the grain was sprouting have shown but little damage at harvest time. In some cases a certain amount of thinning may be beneficial so that unless the damage is great the birds may

perform a real service. The fact that oats is most seriously damaged and that, with the exception of barley and wheat, other grains are not attacked also minimizes the amount of possible damage.

The two other complaints lodged against the western meadowlark—that it is destructive to melons and grapes—have been found to be grossly exaggerated. Some damage is caused to melons by meadowlarks boring into them apparently in search of water or the sweet juice. Melon growers have been quick to complain of the great damage done, but in every case have been unable to demonstrate the real damage in the field. It would also appear that damage to grapes is slight. The meadowlark is not a fruit-eating species, and it seems only natural that it would turn its attention to this kind of food only when forced to by the lack of other food or need of water.

VERDICT OF RANCHERS.

In order that the opinion of the men most directly concerned be not overlooked, a circular letter was sent out to prominent ranchers of the State asking a number of questions. A table showing the answers obtained to the more important questions follows:

Locality.	Number reporting.	Is the meadowlark a nuisance?		Does the meadowlark damage crops?	
		Yes.	No.	Yes.	No.
Northern and central coast counties	19	5	13	6	13
Central valley counties	55	34	21	29	20
Mountain counties	15	1	14	1	14
Southern California	14	2	12	1	12
Totals	103	42	60	37	59
Total northern California	89	40	48	36	46

It will be seen from this table that there is a considerable difference of opinion as to whether the meadowlark does any damage at all. The astonishing thing is that many grain growers do not consider the bird injurious to their crops. It does not seem reasonable to believe that all of these men based their judgment entirely on sentiment. Southern California is almost unanimous in its verdict of "not guilty." Two reasons can be made to account for this—the smaller amount of grain raised and the comparatively small number of meadowlarks there. It is from the great central valleys, the grain-growing sections of the State, that the greater complaint naturally comes. The majority of those reporting have not had crops damaged by western meadowlarks and do not consider the bird a nuisance.

THE FOOD OF THE WESTERN MEADOWLARK.

EXAMINATION OF STOMACH-CONTENTS.

A correct determination of the economic status of a bird is largely dependent on the knowledge of its food. The food of a bird can be roughly determined by watching the bird in the field. The most dependable data concerning the food of most birds, however, is obtained by examining the contents of the bird's stomach. Consequently stomach examination has been largely depended upon to furnish needed evidence as to the food of the birds under investigation.

The food contained in the stomachs of western meadowlarks can be separated into two classes—animal food and vegetable food. The animal food consists largely of insects and other small animals, and the vegetable food of grain and seeds. In determining the economic status of a bird, both the kind and quantity of food must be considered. Hence the results of stomach examination are expressed in the number of each kind of insect found and the percentage of the volume occupied by each kind. The former gives us some idea of the numbers of injurious insects actually destroyed; the latter some idea of the capacity for good or evil and a more accurate idea of the comparative amounts of the different kinds of food taken.

ANIMAL FOOD.

Over half (59.6%) of the food for the year is made up of animal food. The animal food comprises beetles, grasshoppers, crickets, Jerusalem crickets, cutworms, caterpillars, wireworms, bugs, bees, ants, wasps, flies, spiders, and other miscellaneous arthropods.

Beetles form 17 per cent of the total food for the year. From twenty

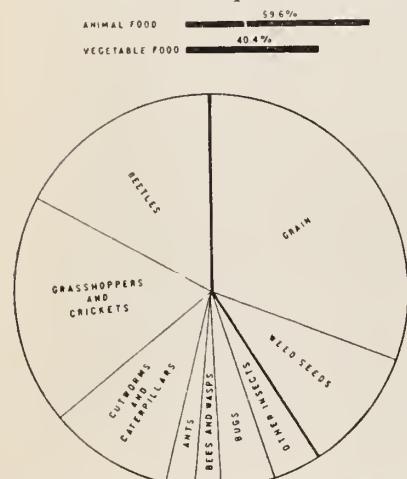


FIG. 4.—Diagram showing relative amounts of different kinds of food taken during the year by western meadowlarks. Computed from the results of the stomach examination of 1200 birds collected in all parts of the State.

tive species found in California are destroyed in great numbers. Crickets (*Gryllus* sp.) and Jerusalem crickets (*Stenopelmatus* sp.) are also taken in large numbers. The jaws of fifteen common black crickets (*Gryllus pennsylvanicus*) were taken from one stomach.

Cutworms and caterpillars form about ten per cent of the total food. Many stomachs have contained as high as twenty large cutworms or caterpillars. One bird taken at Red Bluff, Tehama County, had eaten sixty-six cutworms. Even hairy caterpillars are destroyed.

The commonest true bugs destroyed by western meadowlarks are stink-bugs (*Pentatomidae*), negro-bugs (*Corimelaenidae*), leafhoppers (*Jassidae*), and cicada flies (*Cicadidae*). They form over three per cent of the food for the year. As high as twenty stink-bugs have been taken from a single stomach.

to fifty have often been found in a single stomach. Ground beetles (*Carabidae*, *Tenebrionidae*) are most often taken but such injurious beetles as click-beetles (*Elateridae*), pinacate-beetles (*Eleodes* sp.), leaf-beetles (*Chrysomelidae*), snout-beetles (*Otiorrhynchidae*), and weevils (*Curculionidae*) are destroyed in great numbers. Wireworms, the larvae of click-beetles, are taken in quantity where they are available.

Grasshoppers form about fifteen per cent of the food for the year. Parts of as many as twenty-six large grasshoppers (1 inch or over in length) and fifty-eight small grasshoppers ($\frac{1}{2}$ inch in length) have been taken from single stomachs. Meadowlarks feed almost exclusively on grasshoppers during the summer and fall months. All of the destruc-

Bees and wasps form nearly five per cent of the food for the year. Ichneumon flies, valuable parasitic insects, are frequently taken. Ants form more than one per cent of the food. They are taken irrespective of kind and over one hundred ants have been found in some stomachs. Cow-killers (*Mutillidae*) are occasionally eaten.

Spiders and their egg cases, sow-bugs, centipedes, millipedes, scorpions, and ant-lions are eaten to a less extent. Each forms less than one per cent of the food for the year.



FIG. 5.—Photograph of stomach-contents of a western meadowlark collected at Big Pine, Inyo County, California, April 19, 1911. The stomach contained 13 cutworms, 26 click-beetles (*Drasterius* sp.), and 10 small ground beetles (*Amara* sp.). (Original.)

VEGETABLE FOOD.

The vegetable food of the western meadowlark is made up of grain and seeds, most of the latter being the seeds of weeds. It forms 40.4 per cent of the food for the year, 31 per cent being grain and the rest mostly weed seeds. Sprouted grain makes up less than one per cent of the grain found in the stomachs. As many as thirty kernels of oats with enough hulls to account for as many more have been found in single stomachs. Wild oats is the grain most often taken. One stomach examined contained a few kernels of field corn and about ten others contained varieties of Egyptian corn and Milo maize.

The maximum consumption of weed seed is in October, when almost one fourth of the food is made up of these seeds. Seeds of filaree (*Erodium* sp.) are most often taken. Tarweed, pigweed, tumbleweed, amaranth, mustard, turkey mullein, Napa thistle, Johnson grass, canary grass, foxtail, sunflower, burr clover, and nightshade seeds are the other important weed seeds eaten. Over one hundred seeds of filaree have been taken from a single stomach. After plowing begins weed seeds are not available in cultivated districts except along fence rows and in uncultivated fields, so it seems natural that the maximum number eaten are taken in the fall months.

No vegetable matter found in the stomachs has been identified as fruit. Grape seeds have been found in a number of cases, and there is no doubt but that western meadowlarks eat grapes to a slight extent. No serious complaint as to their depredations in this direction has been received. The stomachs of practically all of the birds collected in vineyards have been filled with insects—mostly beetles.

VARIATION OF KIND OF FOOD WITH TIME OF YEAR AND LOCALITY.

The kind of food taken by the western meadowlark varies greatly from month to month. During the spring and summer, when insects are plentiful, this bird feeds almost exclusively on insects. During the fall and winter when insects are no longer abundant it turns its attention to weed seeds and grain. The accompanying diagram (Fig. 6) showing the amount of animal and vegetable food taken by meadow-larks collected each month at Red Bluff, Tehama County, clearly brings out the change in food habits from one part of the year to another.

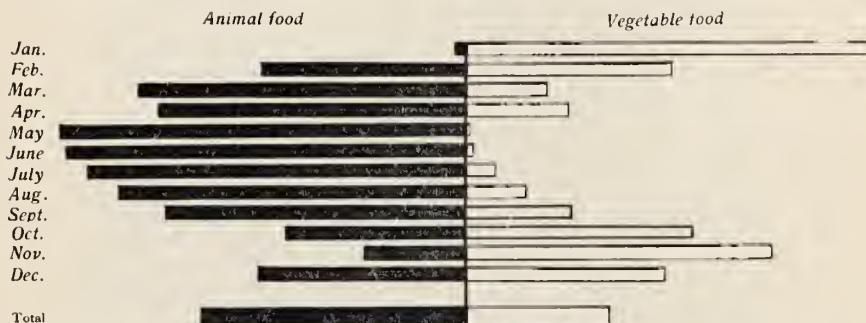


FIG. 6.—Diagram showing change of food-habits of the western meadowlark from month to month. Note that the maximum consumption of animal food is to be found in May, June, and July, and the minimum corresponding with the maximum of vegetable food, in January and February. Computed from the result of the stomach examination of an average of twelve birds taken each month during 1911 at Red Bluff, Tehama County, California.

The investigation has shown that the proportions of the different kinds of food taken by western meadowlarks varies from one locality to another. Birds collected in the vicinity of San Diego took a less percentage of insects than those collected at Riverside and San Bernardino. Birds collected in the vicinity of Ukiah, Mendocino County, took larger numbers of click-beetles than birds from any other locality. Stomachs of birds collected in the vicinity of Hollister, San Benito County, contained extraordinarily large quantities of erickets. Hanford, Kings County, birds fed very extensively on cutworms. Birds collected at Newman, Stanislaus County, contained extra large percentages of stink-bugs and grasshoppers. Birds from Red Bluff, Tehama County, Live Oak, Yuba County, Sacramento, Sacramento County, Newman, Stanislaus County, and Los Banos, Merced County, took very nearly the same proportion of animal and vegetable food.

Meadowlarks collected in alfalfa fields were found to have consumed larger quantities of cutworms and caterpillars than birds taken in grainfields or orchards. The accompanying table makes a comparison of the food of birds collected in alfalfa, grain, orchards, and vineyards.

Comparison of Food Taken by Western Meadowlarks Collected In Alfalfa fields, Grain-fields, Orchards, and Vineyards.

Averages of ten birds collected in March, April and May, 1911, at Hanford, Kings County, California.

Kind of field.	Per cent animal food.	Per cent vegetable food.	Average number of beetles.	Per cent beetles.	Average number of cutworms and caterpillars.	Per cent cutworms and caterpillars.
Alfalfa -----	95.9	4.1	5.1	24.1	11.2	61.4
Grain -----	99.4	.6	9.4	58.5	1.8	21.0
Orehard -----	98.3	1.7	4.8	31.7	6.5	55.7
Vineyard -----	78.3	21.7	1.0	5.0	7.0	42.0

Birds collected in pasture land have usually shown slightly larger percentages of insects than those collected in grainfields.

All of this evidence goes to prove that the western meadowlark varies its food-habits with the abundance of available food. If the bird relied entirely on certain kinds of insects, its usefulness would be less apparent. The fact that it turns its attention to the insect most abundant emphasizes its function in helping to maintain a desired balance.

FOOD OF NESTLINGS.

Examination of the stomachs of nestling birds has shown that they are fed very largely on cutworms, caterpillars, grasshoppers, and ground beetles. In almost no instance has grain or weed seed been found in the stomachs. The increased consumption of insects due to the demands of young birds comes at a time when there are growing crops which need protection and when insects are most numerous, thus emphasizing the value of birds as balancers. The fact that meadowlarks show a greater preference for certain kinds of insect food while feeding the young enlarges their sphere of usefulness.

QUANTITY OF FOOD.

In addition to the evidence furnished by stomach examination, certain experiments have been carried on to determine the quantity of food consumed by western meadowlarks and the time of digestion.

The time of digestion was determined by feeding young birds and examining the stomachs after different periods of time had elapsed. The results of the experiments showed that western meadowlarks must completely digest a meal inside of four hours. It was found that grain takes longer to digest than do insects. Thus it can be seen that the food found in the stomach at any one time does not represent the amount of food taken daily, but only about a third part of that consumed daily.

The stomach of an adult male western meadowlark will hold on an average about three cubic centimeters of food. The female bird averages about two and one half cubic centimeters. Taking an average of two and three quarters cubic centimeters and considering that each bird fills its stomach at least three times a day, one hundred western meadowlarks must consume near a liter or about a quart of food each day. If the food be grain, it can be seen that the amount of destruction is considerable. If the food be insects, it can be seen that meadowlarks take a large daily toll of insects. The same type of computation shows that a western meadowlark must consume at least six pounds of food a year.

Some idea of the average numbers of the common insects, grain and

weed seeds destroyed each meal by western meadowlarks can be obtained from the following table, which was computed from the results of stomach examinations of birds collected at Sacramento, California. The average for the day is three times that for each meal.

Average Numbers of Common Insects, Grain and Weed Seeds Destroyed by Western Meadowlarks at Sacramento, California.

Number of birds.	Time of year.	Average number per bird of—					
		Grain.	Weed seeds.	Beetles.	Cut- worms and cater- pillars.	Grass- hoppers.	Ants, bees and wasps.
14---	February to April, inclusive-----	-----	5.7	4	8.0	-----	-----
11---	Sept. to Nov., inclusive-----	2.5	86.2	2	2.2	2.6	1

Few people have any realization of the great quantities of insects consumed by birds. For instance, if we consider that there is an average of one meadowlark to every four acres of available land for cultivation (11,000,000 acres) in the Sacramento and San Joaquin valleys, and that each pair of birds raises an average of four young, each one of which averages one ounce in weight while in the nest and consumes its own weight of food each day, it takes 193 tons of insect food each day to feed the young birds in the great valleys alone. The numbers of birds probably exceed the number suggested. The increased consumption of insect food due to nestling birds comes at a time when insects are most numerous, and so is instrumental in helping to prevent an undue increase of insects.

A very conservative estimate of the approximate amount of the different kinds of food consumed by the average meadowlark in California during the year is as follows:

Grain -----	1½ pounds
Weed seed -----	½ pound
Insects -----	2½ pounds
Total -----	6 pounds

RELATION TO INSECT OUTBREAKS.

Studies have been made of the relation of birds to two insect outbreaks; one, an outbreak of butterflies (*Eugenia californica*) in northern California during the summer of 1911, and second, a grasshopper outbreak in Merced County in the summer of 1912.

Although butterflies are usually considered unpalatable, yet it was found that Brewer blackbirds were feeding almost entirely on them, and that western meadowlarks and several other birds took them to a slight extent.

Investigation showed that meadowlarks in Merced County averaged more grasshoppers per day during the outbreak in 1912 than in 1911, when the insects were not so abundant. The following table compares the numbers taken in the two years:

Number of birds.	Date.	Per cent animal food.	Per cent vegetable food.	Average number grass- hoppers per bird.	Total per cent grass- hoppers.
10---	July 11, 22, 1911-----	99.0	1.0	7	83.1
5---	July 15, 17, 1912-----	99.2	.8	16	96.2

Next to the red-winged blackbird the western meadowlark proved to be the most efficient destroyer of grasshoppers, not only because of its numbers, but also because of their high average.

The following facts have been demonstrated by these investigations of insect outbreaks:

1. Birds cannot be considered a dependable means of completely controlling all insect outbreaks, but can be inferred to be instrumental in the prevention of many.

2. Birds can be depended upon to act as defenders and protectors of crops because of their warfare against insect pests.

3. Birds change their food-habits and feed on the insect most abundant, thereby making them important maintainers of the desired balance in nature.

4. The failure of birds to check an insect outbreak is evident to all. Their success in preventing insects from becoming abnormally abundant is not so apparent, but none the less real. All obtainable evidence points to the fact that the regulative influence exerted by birds when insects are to be found in normal numbers, though less apparent, is none the less important, for at such times artificial control measures are seldom used.

5. Birds which, on account of their abundance, cause serious losses to the agriculturist often become for the same reason the most efficient insect destroyers at the time of an insect outbreak.

6. Birds fill a niche in the balance of nature which is not and cannot be filled by any other form of life. Their destruction, therefore, causes a dangerous disturbance of that balance of nature most suited to mankind.

THE ECONOMIC STATUS OF THE WESTERN MEADOWLARK.

A correct determination of the economic value of any bird is dependent on a comparison of its injuries with its benefits. Such a comparison is presented for the western meadowlark as follows:

INJURIES.

1. Destroys sprouting oats, barley, and wheat.
2. Destroys some beneficial insects.

BENEFITS.

1. Destroys in greater or less quantity almost every important insect pest found in grain fields.
2. Is important as a protector of crops at the time of an insect outbreak and perhaps more important when insects are in normal numbers.
3. Destroys the seeds of many serious weed pests.
4. Feeds in places that other birds do not frequent, thereby destroying pests not destroyed by other birds.

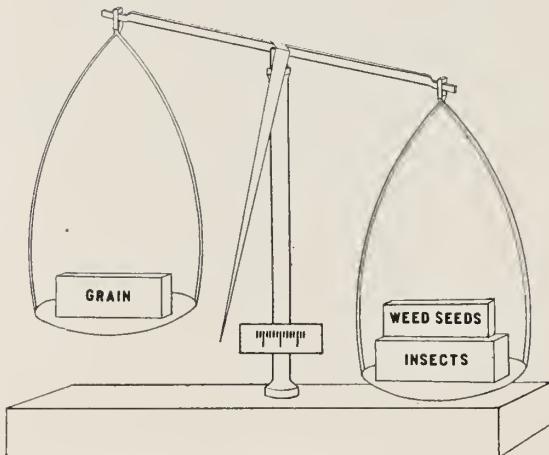


FIG. 7.—The destruction of insects and weed seeds accorded by the western meadowlark more than balances its destruction of grain.

Those factors which make the depredations of the western meadowlark important and those factors which minimize the damage done may be summarized as follows:

1. Method of pulling sprouting grain.
2. Lack of insect food when grain is sprouting.
3. Availability of grain at the time when insects are at a minimum.
4. Flocking habit.
5. Abundance of meadowlarks in grain-growing localities.
6. Great capacity and rapid digestion.
1. Boring habit valuable in securing such insects as cutworms and wireworms.
2. Take a larger percentage of insects than of grain during the year.
3. Time during which damage can result limited.
4. Flocking habit makes control measures easier.
5. Abundance of meadowlarks assures more efficient destruction of insect pests.
6. Great capacity and rapid digestion improves their value as insect destroyers. Slower digestion of grain than of insects makes a less consumption of the former.
7. Do not destroy other crops.
8. Apparently driven to grain only when insects are not available.
9. Prefer uncultivated land.
10. Unable to cause serious damage when grain is planted deeply.

The causes for and against protecting the western meadowlark may be summarized as follows:

AGAINST PROTECTION.

1. Destroys sprouting grain.
2. Eats grain during winter months.
3. Destroys sprouting seeds.
4. Destroys some beneficial insects.

FOR PROTECTION.

1. Destroys quantities of injurious insects.
2. Destroys weed seed.
3. Fills important niche in the economy of nature.
4. Has great esthetic value.
5. Depredations limited to two weeks' time on any one field and limited to grain-growing districts.

It must be apparent from these comparisons that the balance is certainly in favor of the meadowlark. Birds are considered a national resource and so belong to the people as a whole. It even seems doubtful whether the grain grower should destroy birds damaging his crops when the same birds might be performing a great service in destroying injurious insects in his own or his neighbor's alfalfa field.

It is readily acknowledged that birds are not the only checks of the increase of insects. The very large toll taken by them, however, places them in the front rank as insect destroyers. Parasites only become abundant when their hosts becomes abundant. Birds, in order to keep alive, must wage a continual warfare on insect life, no matter what the abundance. They are evidently, therefore, to be relied upon as more dependable regulators than parasites.

Since, as has been shown, the average adult western meadowlark destroys nearly three pounds of insects each year and probably almost as many more pounds while feeding its young, its value to the agriculturist is apparent. The value of one of these birds living to one dead is, therefore, as five pounds of insects and one half pound of weed seeds is to one and three fourths pounds of grain, a considerable portion of which is made up of wild oats and waste grain.

The fact that the western meadowlark destroys certain beneficial

insects cannot be counted a point in its favor. And yet, the quantity taken is so small, less than five per cent of the food for the year, and the destruction so caused is such an indirect injury that the damage possible is very slight and practically negligible. The destruction of an ichneumon compared with the destruction of one hundred grasshoppers, somewhat the proportion in which they are taken, leaves no doubt as to the comparative benefit to be derived.

The investigation has shown that the western meadowlark deserves protection and encouragement at the hands of the agriculturist. Only in rare cases can it be said that the bird does more harm than good. One and three fourths quarts of insects taken by a western meadowlark during a year more than pays for less than one quart of grain, a large part of which does not represent a loss.

The present law which provides for the killing of any bird found destroying crops by the owner or tenant of a place seems adequate at the present time. A law taking protection from the meadowlark is not justified by the results of the investigation.

SUGESTIONS FOR THE PROTECTION OF CROPS.

Where losses to crops warrant protective measures, the following are proposed:

1. Plant grain deeply. It secures a better crop regardless of losses due to meadowlarks. Drilled grain gives a better yield than broadcasted and is also better protected from the attack of meadowlarks. (See University of California Publ., Agricultural Experiment Station, Bulletin 211, p. 278.)
2. Fields bordering pasture or uncultivated land, if sowed more heavily along such margins will assure a normal crop.
3. Meadowlarks are easily frightened from a field by shooting or by a dog. As damage is limited to a short period of time, this method seems practical on small fields.
4. Under extreme conditions meadowlarks may be easily reduced in numbers by the use of a shotgun.

SUMMARY.

Owing to the constant complaint of ranchers as to the depredations of birds throughout the State, the California State Fish and Game Commission in cooperation with the University of California has undertaken a thorough, scientific investigation into the relation of certain birds to agricultural interests. The western meadowlark has been the first one to receive attention.

The investigation has included field investigation, experimentation, and a study of the food-habits of the bird for the whole year by an examination of the stomach-contents of birds collected for the purpose each month of the year and in over twenty-five different localities in the State.

Field investigation has shown that the western meadowlark destroys sprouting grain. The amount of damage varies with the depth of planting, the size of the field, the condition of the soil, the proximity to pasture or uncultivated land, and the abundance of the birds.

Stomach examination has shown that 60 per cent of the food for the year is made up of animal matter, and 40 per cent of vegetable matter. The animal matter is made up almost entirely of insects, most of which are injurious to crops. Ground beetles, grasshoppers, crickets, cut-worms, caterpillars, wireworms, stink-bugs, and ants form the principal items. All of these insects are destroyed in great numbers. The vegetable food is made up of grain and weed seeds. Grain as food reaches a maximum in November, December and January.

The verdict of ranchers throughout the State obtained by a circular letter has shown that there is a wide difference of opinion as to the extent of damage caused by the meadowlark. More than one half maintain that the meadowlark does not damage crops and is, therefore, not a nuisance.

Experimentation has shown that the western meadowlark has an average capacity of two and three fourths cubic centimeters and that the stomach contents is digested within a period of four hours, thus making the daily consumption at least three times the capacity. Young birds need very near their own weight of food daily and are fed entirely on insects.

Western meadowlarks turn their attention to the insect most abundant, thereby increasing their efficiency at the time of an insect outbreak. They bear an important relation to grasshopper outbreaks, and to other insect outbreaks as well.

When the benefits conferred by the western meadowlark are balanced with the injuries, there remains no doubt that the bird deserves protection and encouragement. Its value as a destroyer of injurious insects far exceeds its detriment as a destroyer of sprouting grain. The value of a western meadowlark living to one year is as five pounds of insects (mostly injurious) and one half pound of weed seeds is to one and three fourths pounds of grain, a considerable part of which is made up of wild oats and waste grain.

Present laws seem adequate to assure both the bird and the rancher sufficient protection.

A strong point favoring the protection of the western meadowlark is to be found in the fact that the only real damage caused (that to sprouting grainfields) can be largely prevented by planting grain deeply and drilling instead of broadcasting, two measures highly advocated by all agricultural experiment stations as favoring larger crops.

PROTECTIVE MEASURES.

Where protective measures are found necessary, the following are recommended:

1. Deep planting.
2. Drilling as against broadcasting.
3. Heavier sowing along margins of fields bordering on pasture or uncultivated land.
4. Frightening from fields.
5. As a last resort, the use of the shotgun.